Wearable Augmented Reality System Using Invisible Visual Markers and an IR Camera

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Abstract

This paper describes a wearable augmented reality (AR) system using invisible visual markers. Some AR systems use visual markers in order to measure the position and orientation of user's viewpoint. However, conventional visual markers usually impair the scenery. This paper proposes a system using invisible visual markers consisting of translucent retro-reflectors. The system can be realized without undesirable visual effects and power supply for infrastructures.

1 Introduction

The AR technique which merges the real and virtual worlds has received a great deal of attention as a new method for displaying location-based information in the real world. Therefore, AR systems using wearable computers like navigation systems have been proposed. To realize an AR system using a wearable computer, the exact position and orientation of a user are required. Especially in indoor environments, since a GPS cannot be used, many localization methods have been proposed[1, 2]. One of the methods estimates the user's position by recognizing visual markers pasted up on the ceilings or walls. For example, Baratoff, et al. [3] have used ARToolKit [4] square markers. Naimark, et al. [5] have developed a system that stably estimates the position and orientation of the user by combining an accelerometer with a camera which captures circular markers. However, these methods have some problems concerning undesirable visual effects.

In order not to impair the scenery, we employ a localization method which is based on using invisible visual markers that consist of translucent retro-reflectors[6]. In the method, user's position and orientation are estimated by recognizing invisible visual markers which are illuminated from IR LEDs. This paper describes a wearable AR system which is based on using the invisible marker based localization method.

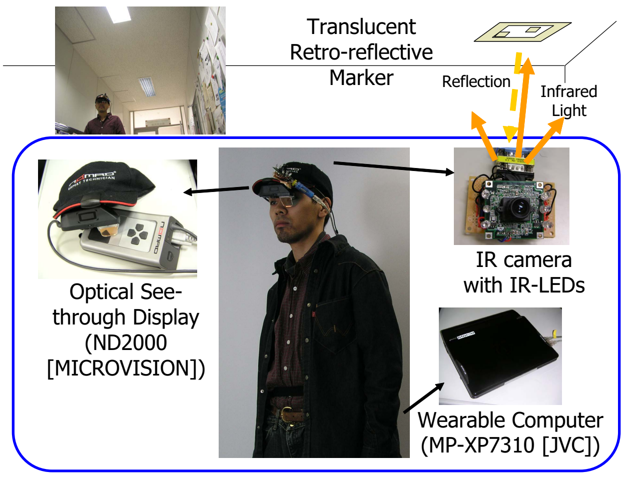

Figure 1. Wearable augmented reality system overview.

2 Wearable Augmented Reality System

Figure 1 illustrates the overview of the proposed wearable AR system. Markers consisting of translucent retro-reflectors are set up on the ceilings or walls in indoor environments as infrastructures. Since the markers are translucent, it is difficult for a human to observe the markers. The user equips an optical see-through display and an IR camera upward for capturing images. The camera captures the reflection of the IR LEDs that are attached to it. The retro-reflector reflects a light toward a light source and thus its reflection can be captured clearly by the IR camera located near the IR LEDs as shown in Figure 2. From a captured image, the regions of markers are extracted, and IDs associated with the markers are recognized. In addition to identifying the received marker, it is possible to estimate the relative position and orientation of camera with respect to the marker coordinate system from four vertices of a square marker of known size using a standard computer vision technique[4]. Finally, the system draws the virtual object images such as

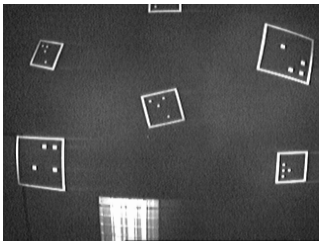

Figure 2. Image captured by an IR camera with IR LEDs.

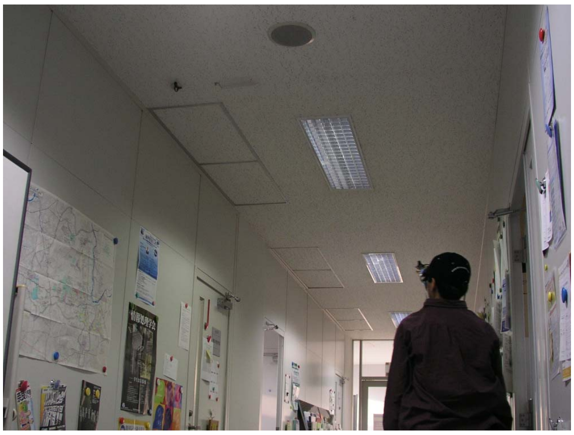

Figure 3. Experimental environment: Invisible visual markers are setup on the ceiling.

annotation overlay images based on estimated user's position and orientation.

3 Experiments

In this experiment, a prototype wearable AR system shown in Figure 1 is used. View angle of the IR camera is $92.6°$ and the image size is 320×240 pixels. The experimental environment is shown in Figure 3. In the environment, invisible visual markers are setup on the ceilings. There are 78 markers on $18m \times 3m$. When the distance between IR camera and ceilings was $1.2m$, the error of estimated user's position and and its standard deviation were about $10cm$and $8cm$, respectively. Moreover error of estimated user's orientation was about $5°$ and its standard deviation was $5°$.

Figure 4 shows an example of annotation overlay images generated by the prototype system. In this experiment, we confirmed that wearable AR system can be realized without undesirable visual effects and power supply for infrastructures.

4 Conclusion

This paper has proposed a wearable AR system using invisible visual markers which consist of translucent retro-

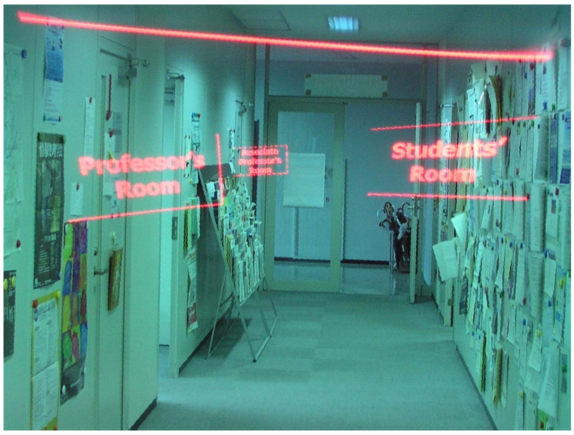

Figure 4. Annotation overlay image.

reflectors and an IR camera. In the system, user's position and orientation are estimated by recognizing the markers illuminated from IR LEDs. In the experiment of a prototype system, we have confirmed that the system can be realized without undesirable visual effects and power supply for infrastructures. In future work, we should carry out experiments in wide indoor environments.

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